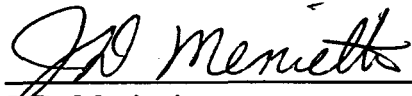


Title of Grant	Polar Plasma Wave Investigation Data Analysis in the Extended Mission
Type of Report	Final Report (Summary of Research)
Name of Principal Investigator	Donald A. Gurnett
Period Covered by the Report	April 1, 2002 through December 31, 2004
Name and Address of the Recipient's Institution	The University of Iowa Sponsored Programs 100 Gilmore Hall, Room 2 Iowa City, IA 52242
Grant Number	NAG5-11942
Signature	Prepared by:  J. D. Menietti

1.0 Purpose

This Summary of Research is being submitted to NASA Goddard Space Flight Center in fulfillment of the annual reporting requirement under Grant NAG5-11942. This summary includes some details of a few exemplary accomplishments of the Polar Plasma Wave Investigation known during the period April 1, 2002, to November 1, 2004, and a list of publications and pending publications during that same period. The website link to the Polar/PWI publications is as follows:

<http://www-pw.physics.uiowa.edu/plasma-wave/istp/polar/publications.html>

2.0 Summary of Exemplary Accomplishments

ELF/VLF plasma waves in the low latitude boundary layer

B. T. Tsurutani, G. S. Lakhina, L. Zhang, J. S. Pickett, and Y. Kasahara
in *Earth's Low-Latitude Boundary Layers, Geophysical Monograph 133*, eds. P. Newell and T. Onsager, pp. 189-203, doi:10.1029/133GM19, American Geophysical Union, Washington, DC, 2003.

Abstract. The low latitude boundary layer (LLBL) is a region where solar wind momentum and energy is transferred to the magnetosphere. Enhanced "broadband" electric plasma waves from < 5 Hz to 10^5 Hz and magnetic waves from < 5 Hz to the electron cyclotron frequency are characteristic of the LLBL. Analyses of Polar plasma waves show that these "broadband" waves are actually discrete electrostatic and electromagnetic modes as well as solitary bipolar pulses (electron holes). It is noted that all wave modes can be generated by ~ 100 eV to ~ 10 keV auroral electrons and protons. We will review wave-particle interactions, with focus on cross-diffusion rates and the contributions of such interactions toward the formation of the boundary layer. In summary, we will present a scenario where the global solar wind-magnetosphere interaction is responsible for the auroral zone particle beams, and hence for the generation of plasma waves and the formation of the boundary layer. It is speculated that all planetary magnetospheres will have boundary layers and they will be characterized by similar currents and plasma wave modes.

Frequency-time spectra of magnetospherically reflecting whistlers in the plasmasphere

J. Bortnik, U. S. Inan, and T. F. Bell
J. Geophys. Res., 108, A1, 1030, doi:10.1029/2002JA009387, 2003.

Abstract. We present a numerical method of simulating at any location in the magnetosphere, the observed frequency versus time (f-t) spectrogram resulting from a lightning strike at any given latitude on Earth. Using a two-dimensional ray tracing code, we calculate the trajectories of 5330 whistler rays that effectively sample the lightning strike's frequency spectrum and latitudinal spread about the source and then use these so-called "sample rays" to create ~ 120 million interpolated rays, each weighted with a measure of energy according to its frequency and injection latitude. This energy is progressively attenuated along the ray's trajectory using a

Landau damping calculation with realistic suprathermal electron fluxes. A detection area is defined in the plasmasphere, and rays that cross this area are used to construct the f-t spectrogram representative of what would be observed on a satellite located in that region. We investigate the role that the lightning source latitude, observation location, and plasmaspheric electron density structures have on the appearance of the simulated f-t spectrograms and show that all three parameters exhibit distinct and well-defined effects. In particular, we focus on plasmaspheric electron density structures and explain the connection between these structures and the appearance of specific observed features in the spectrograms. Using this analysis, it may be possible to crudely infer certain features of the source and plasmasphere from observed magnetospherically reflecting whistler spectrograms.

High resolution observations of continuum radiation

J. D. Menietti, O. Santolik, J. S. Pickett, and D. A. Gurnett

Planet. Space Sci., in press, 2004.

Abstract. The Polar spacecraft has identified near-source regions of continuum emission in the plasmapause and outer plasmasphere. As in the case of kilometric continuum (KC), near-source regions of continuum emission often display a high resolution fine structure of closely-spaced bands of emission. The separation of the bands is much less than the local gyrofrequency. This suggests that the source is associated with density structures, and perhaps the result of trapped eigenmodes. These results imply further that continuum emission is the low-frequency manifestation of kilometric continuum emission.

Polar observations of plasma waves in and near the dayside magnetopause/magnetosheath

J. D. Menietti, J. S. Pickett, G. B. Hospodarsky, D. A. Gurnett, and J. D. Scudder

Planet. Space Sci., in press, 2004.

Abstract. The plasma wave instrument (PWI) on board the Polar spacecraft made numerous passages of the dayside magnetopause and several probable encounters with the magnetosheath during the years 1996 and 1997. During periods of relatively high density the PWI antenna-receiver system is coupled to the plasma and oscillates. The oscillations have been shown [cf. Beghin and Kolesnikova, 1997; 1998] to be indicative of periods of higher plasma density and plasma flows, possibly associated with magnetic reconnection. We have studied the plasma waves observed on three distinct magnetopause passes distinguished by the presence of these oscillations of the PWI receivers, and we report on the data obtained near but not during the times of the oscillations. Sweep-frequency receiver and high resolution waveform data for some of these times is presented. The plasma wave measurements on each of the passes is characterized by turbulence. The most stable waves are whistler mode emissions typically of several hundred hertz that are seen intermittently in these regions. The data indicate the presence of impulsive solitary-like wave structures with strong electric fields both parallel and perpendicular to the magnetic field, near, but not always within, suspected reconnection sites. The solitary waves show the highest occurrence when observed with electrostatic electron cyclotron waves. These latter waves have been observed in the past in the cusp, polar magnetosphere, and auroral regions and therefore may represent excursions into the cusp, but also indicate the presence of low-energy electron beams. Turbulence near the lower hybrid frequency, low-frequency EM waves, and

impulsive monopolar electrostatic pulses are seen throughout the magnetopause and particularly near regions of large decrease in the local magnetic field and enhanced field-aligned flows, the suspected reconnection sites. The absence of significant solitary wave structures within suspected reconnection sites may require modifications to some reconnection models.

3.0 A list of all of the publications that resulted from work carried out partially or wholly under the subject grant during 2004 is as follows:

Recent Publications in 2004:

Magnetosheath-cusp interface

S. Savin, L. Zelenyi, S. Romonov, I. Sandahl, J. Pickett, E. Amata, L. Avanov, J. Blecki, E. Budnik, J. Buechner, C. Cattell, G. Consolini, J. Fedder, S. Fuselier, H. Kawano, S. Klimov, V. Korepanov, D. Lagoutte, F. Marcucci, M. Mogilevsky, Z. Nemecek, B. Nikutowski, M. Nozdrachev, M. Parrot, J. L. Rauch, V. Romanov, T. Romantsova, C. T. Russell, J. Safrankova, J. A. Sauvaud, A. Skalsky, V. Smirnov, K. Stasiewicz, J. G. Trotignon, Yu. Yermolaev
Ann. Geophys., 22, 183-212, 1-1-2004.

Effective collision frequency due to ion-acoustic instability: Theory and simulations

P. Hellinger, P. Travnicek, and J. D. Menietti
Geophys. Res. Lett., 31, L10806, doi:10.1029/2004GL020028, 2004.

Polar observations of plasma waves in and near the dayside magnetopause/ magnetosheath

J. D. Menietti, J. S. Pickett, G. B. Hospodarsky, J. D. Scudder, and D. A. Gurnett
Planet. Space Sci., in press, 2004.

High-resolution observations of continuum radiation

J. D. Menietti, O. Santolik, J. S. Pickett, and D. A. Gurnett
Planet. Space Sci., in press, 2004.

Electron density in the magnetosphere

R. E. Denton, J. D. Menietti, J. Goldstein, S. L. Young, and R. R. Anderson,
J. Geophys. Res., *J. Geophys. Res.*, 109, No. A9, A09215, doi:10.1029/2003JA010245, 2004.

Occultations of auroral kilometric radiation in the vicinity of the Earth

K. T. Murata, W. Kurth, K. Hashimoto, and H. Matsumoto
Proceedings of the COSPAR Colloquium on Frontiers of Magnetospheric Plasma Physics, in press, 2004.

Latitude-energy structure of multiple ion beamlets in Polar/TIMAS data in plasma sheet boundary layer and boundary plasma sheet below 6 R_E radial distance: Basic properties and statistical analysis

P. Janhunen, A. Olsson, W. K. Peterson, and J. D. Menietti
Ann. Geophysicae, in press, 2004.

Geotail, Polar, and Wind observations of auroral kilometric radiation

R. R. Anderson, H. Matsumoto, K. Hashimoto, H. Kojima, Y. Kasaba, M. L. Kaiser, J. -L. Steinberg, and G. Rostoker
Proceedings of the COSPAR Colloquium on Frontiers of Magnetospheric Plasma Physics, submitted, 2004.

Observational study of generation mechanism of substorm-associated low-frequency AKR emissions

A. Olsson, P. Janhunen, M. Mogilevsky, J. Hanasz, S. Perraut, J. D. Menietti, and G. K. Parks, in press, 2004.

Papers Submitted:

Interrelation of VLF auroral hiss at high altitudes in polar caps with substorm dynamics of aurora

E. E. Titova, A. G. Yahnin, O. Santolik, D. A. Gurnett, F. Jiricek, J. Smilauer, J. -L. Rauch, F. Lefeuvre, L. A. Frank, and J. B. Sigwarth
Ann. Geophysicae, submitted, 2004.

Alfven waves, discontinuities, proton perpendicular acceleration, and magnetic holes in interplanetary space and the magnetosphere: Intermediate shocks?

B. T. Tsurutani, G. S. Lakhina, J. S. Pickett, F. L. Guarnieri, B. E. Goldstein, and N. Lin,
Nonlinear Processes in Geophysics
 Special Issue devoted to the Alfven Workshop held in Nice, France in April 2004, submitted.

Thermal properties of very cold electrons in the magnetosphere including the high latitude plasmasphere

X. Cao, J. D. Scudder, F. S. Mozer, J. D. Menietti, and C. T. Russell
J. Geophys. Res., submitted, 2003.

Papers in Preparation:

Properties of small amplitude electron phase-space holes observed by Polar

J. R. Franz, P. M. Kintner, J. S. Pickett and L.-J. Chen
 To be submitted to *Nonlinear Processes in Geophysics*, 2004.

Solitary waves observed near and far from Earth

C. L. Grabbe and J. D. Menietti, in preparation, 2004.

Low-frequency plasma waves within an AKR source Region: Possible wave stimulation

J. D. Menietti, O. Santolik, J. D. Scudder, and R. L. Mutel, in preparation, 2004.

Future and On-going Research at the University of Iowa

During the 2004 calendar year we will attempt to complete a number of open PWI science efforts. These include at least the following:

The role of solitary waves in transverse heating of auroral ions, J. D. Menietti, I. W. Christopher, B. Giles, and D. A. Gurnett.

Magnetic component of waves near the proton cyclotron frequency and its harmonics, O. Santolik, J. D. Menietti, J. S. Pickett, D. A. Gurnett, and J. D. Scudder.

On-going Research at Stanford University STAR Laboratory

During the 2004 calendar year we will attempt to complete a number of open PWI science efforts. These include at least the following:

PWI and CEPAD/IES observations on polar of intense VLF chorus emissions and energetic electrons near the magnetic equator, T. F. Bell, U. S. Inan, R. A. Helliwell, and M. Carter, *J. Geophys. Res.*, in preparation.

Anisotropic energetic electron velocity distributions in the plasmasphere and the amplification of whistler mode waves, T. F. Bell, U. S. Inan, and J. D. Scudder, *J. Geophys. Res.*, in preparation.

4.0 Public Outreach

A list of the public outreach activities carried out during the reporting period of the subject grant in which the Polar mission and Polar PWI are listed on the Polar/PWI website given above.